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DECISION SUPPORT SYSTEMS – THE EVALUATION OF HEALTH AND ENVIRONMENTAL IMPACT IN A RADIOACTIVE RELEASE*

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Abstract. The paper illustrates, on a couple of case histories, the experience of a research-oriented team in NIPNE, that is routinely involved in nuclear emergency preparedness and response management activities, with the assimilation, implementation, and application of decision support systems (DSS) of continental reference in Europe, and the development of supportive, domestic radiological assessment tools.

Key words: decision support systems, environment, accidental release.

1. INTRODUCTION

Two applications are discussed, in the light of the lessons derived by the authors – the *ConvEX 3, 2005*, an international alert exercise targeting a CANDU reactor at Cernavoda nuclear power plant, and *Oltenia 07* – a nation-wide drill around a scenario involving transborder effects from a VVER reactor at Kozloduy, Bulgaria.

In May 2005, the International Atomic Energy Agency has conducted a comprehensive nuclear alert exercise, code-named *ConvEx-3*. The drill aimed at verifying the capability of a variety of actors involved in the assessment and mitigative reaction to a significant abnormal event in a nuclear facility, with Cernavoda Nuclear Power Plant, Romania selected as a test ground. The second event related to the organization, by the Romanian General Inspectorate for Emergency Situation, of an emergency drill to test near-site response capabilities in the case of a transborder accidental release at the Kozloduy NPP, on the Danube river.

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2. THE TOOLS

The major decision support system in both exercises was RODOS [1, 2] (*Real-Time, On-Line Decision Support System for the Management of Nuclear Emergencies in Europe*) developed by a multinational research consortium within the EU Framework Programmes 4, 5, and 6. In the domestic league, specific roles were allocated to RAT [2] (*Radiological Assessment Toolkit*) – an open-ended software platform of an MS&V (*Modeling, Simulation and Visualization*) profile that assemblies requisite source term, environmental transport, dosimetric, dose-effect, and dose/derived intervention level-countermeasure correlated facilities substantively linked to GIS and physical data libraries, meant to perform as a RODOS input assistant, an independent assessor, and an on-the-job tester and trainer. RODOS is a heavy-weight facility operating from a graphics station, covering the early (1–7 days) as well as the intermediate and long (ingestion) phases (months, years) in the development of an accidental release, dwelling comprehensively in health, environmental, and economic consequence considerations. RAT ('*Radiological Assessment Toolkit*') [4] is, on the other hand, a lighter-weight player mainly focusing on NIPNE's emergency assistance business – a part of institute's mission statement and it is designed to operate at a PC desktop/laptop level providing prompt and indicative assessments of radioactive inventories, source terms, environmental dispersion dose and derived response levels.

In the cases described, the working sequence went as follows:

Step 1: the ancillary RAT assistant have expeditiously provided 8-hour meteo forecasts emphasizing the wind and precipitation regime at, and near the accident site, with a potential coverage of the mesoscale. To this effect, the RAT team has issued a dedicated software capable of offline-browsing a public meteorological forecast data resource – the *U.S.A. Weather Channel/UK.Weather.com* in order to mine-out parameters of prime consequence in determining the motion and the dispersive properties of masses of air overflowing the release source (Cernavoda and Kozloduy, respectively) areas prior, and during the (simulated) abnormal release. These include *wind direction and speed*, *cloud cover*, and *precipitation.*

Step 2 has seen RODOS at work, given the input described.

The source terms were back-engineered, trial-an-error fashion, from the doses that would warrant certain responses on certain areas, as deemed adequate by the drill planners. While the Cernavoda exercise relied on source terms recommended in the literature, the Kozloduy scenario employed a modified source term for a VVER 1000 reactor available in the database of the RODOS system itself.

For the regional scenario, contamination of part of the Danube river catchments was simulated taking ino account the radioactive release postulated for Day-1. Fallout of Cs-137 and Sr-90 was calculated using RODOS, and the results were used to estimate radiological consequences by hydrological pathways, using the 1D aquatic transport module of RODOS system. Another important result of RODOS concerned the evaluation of the radiological impact of *tritium* – a nuclide expected to abound in releases from CANDU reactors like the one at Cernavoda. The results of the assessment of the tritium impact via the *inhalation* and *ingestion* were also requested by decision makers during the ConvEx exercise.

In its turn, the RAT team has conducted independent assessments based on its own capabilities of generating and integrating source terms, site meteorology, and dispersion and dosimetric models to the effect of generating *diagnostic*, *i.e.* countermeasure-oriented, and *prognostic* – *i.e.* vulnerability assessment-oriented situation reports and consequent recommendations for action.

3. RESULTS AND CONCLUSIONS

By intent and design, the decision support tools assimilated and developed in NIPNE observe a strategy of balanced interaction with the decision-making, laymen-dominated, environment: *respond* to their needs, yet also *format and guide* their needs in tune with internationally-recommended standards and regulations.

The first information required by the decision makers has targeted the appropriateness of *early countermeasures* – sheltering and evacuation of population, administration of iodine tablets – and the dose levels expected in the potentially affected area. Fig. 1 illustate some visual segments of the comprehensive documentation files that substantiate the countermeasure guidance. Based on this evaluation the RODOS system recommended [3] the administration of iodine tablets to children, in the specified and charted area.

As indicated, RAT [4] has also engaged in a corroborative *radiological assessment* and the *countermeasure design*. However, in contrast with RODOS – that was bearing the prime responsibility for issuing, near-real time manner, information of immediate relevance for directing the response, RAT has adopted a strategy of *alternative situations coverage,* based on *'what if'* scenarios, that means preventive knowledge of what the doses should be e.g. *if* the atmosphere is class A, or B, C, D, E, F; and *if* the release can be categorized as 'ground', or 'elevated'; and *if* the release was, or was not, under rain. Fig. 2 illustrates countermeasure areas following from RAT assessments conducted as described. Samples of the output offered to decidents in the preparation of, and during the OLTENIA drill are given in Fig. 3.

The running of both DSSs in the second day of the drills has demonstrated a sound capability of absorbing feedback from (simulated) field measurement data collected by the response teams, and of remaking, on this basis, the radiological assessment in view of updating and adjusting the recommendations for action.

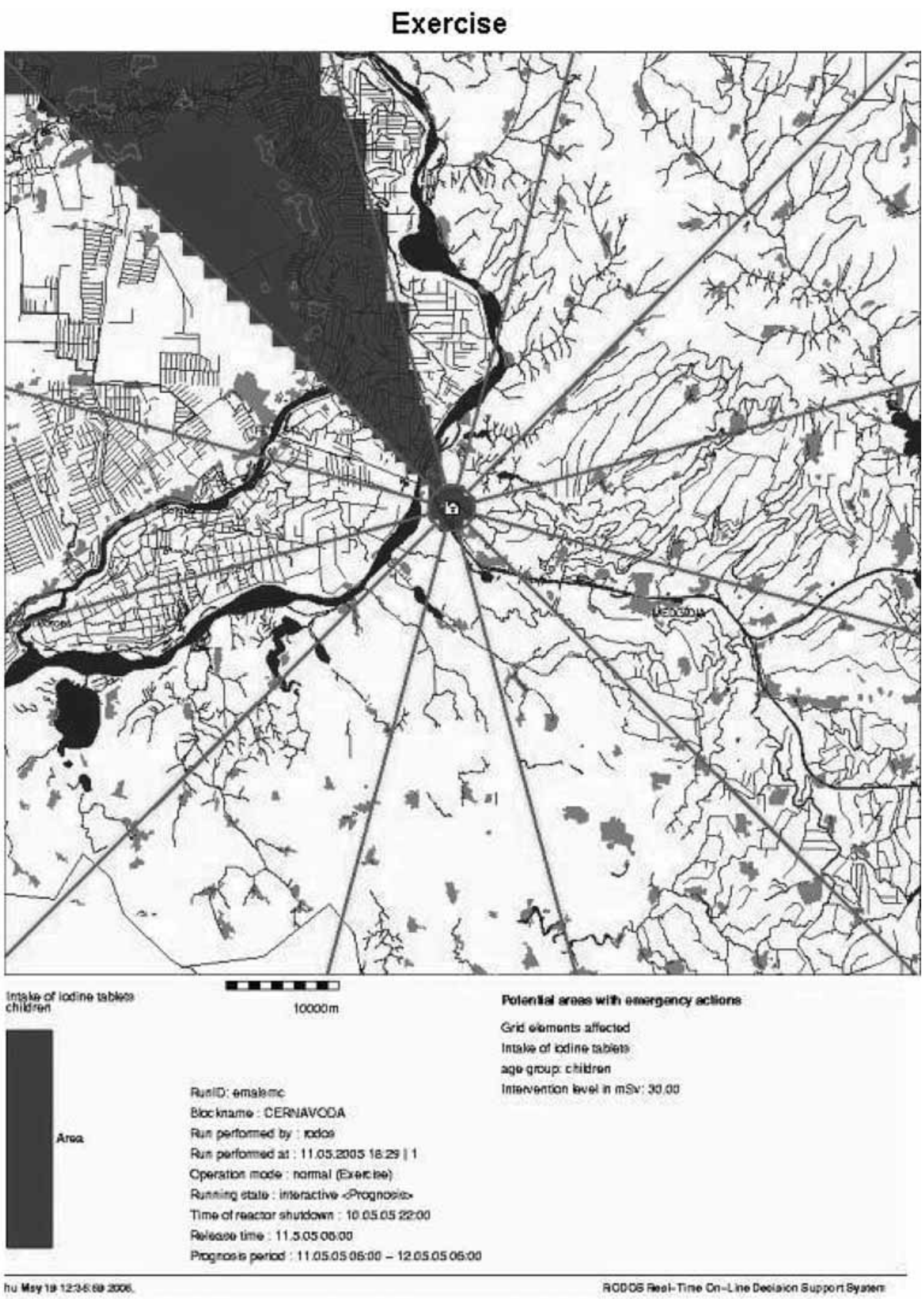

Fig. 1 – a) Potential area affected by countermeasures: administration of iodine tablets for children.

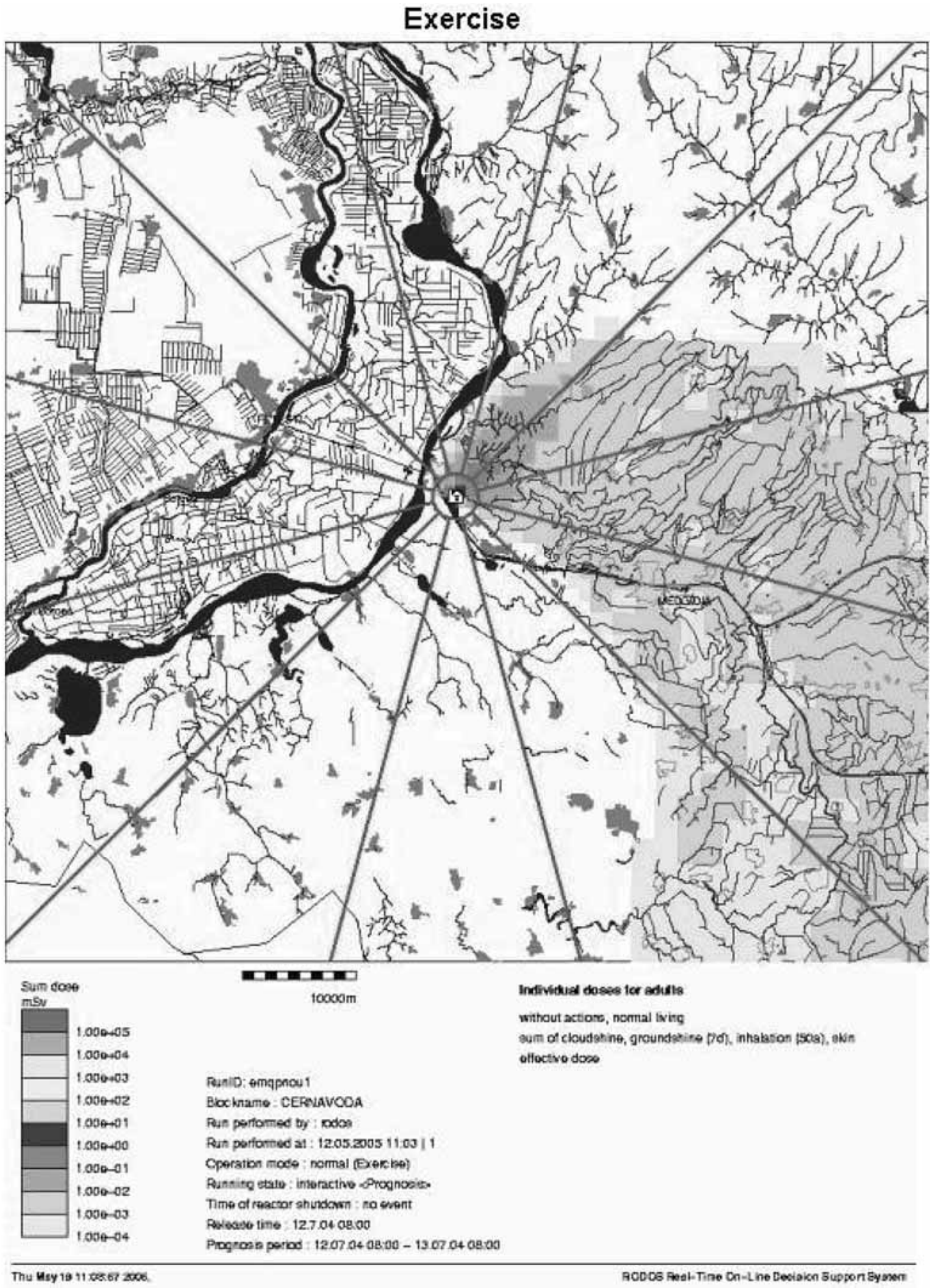

Fig. 1 – b) effective doses for adults after the second day release.

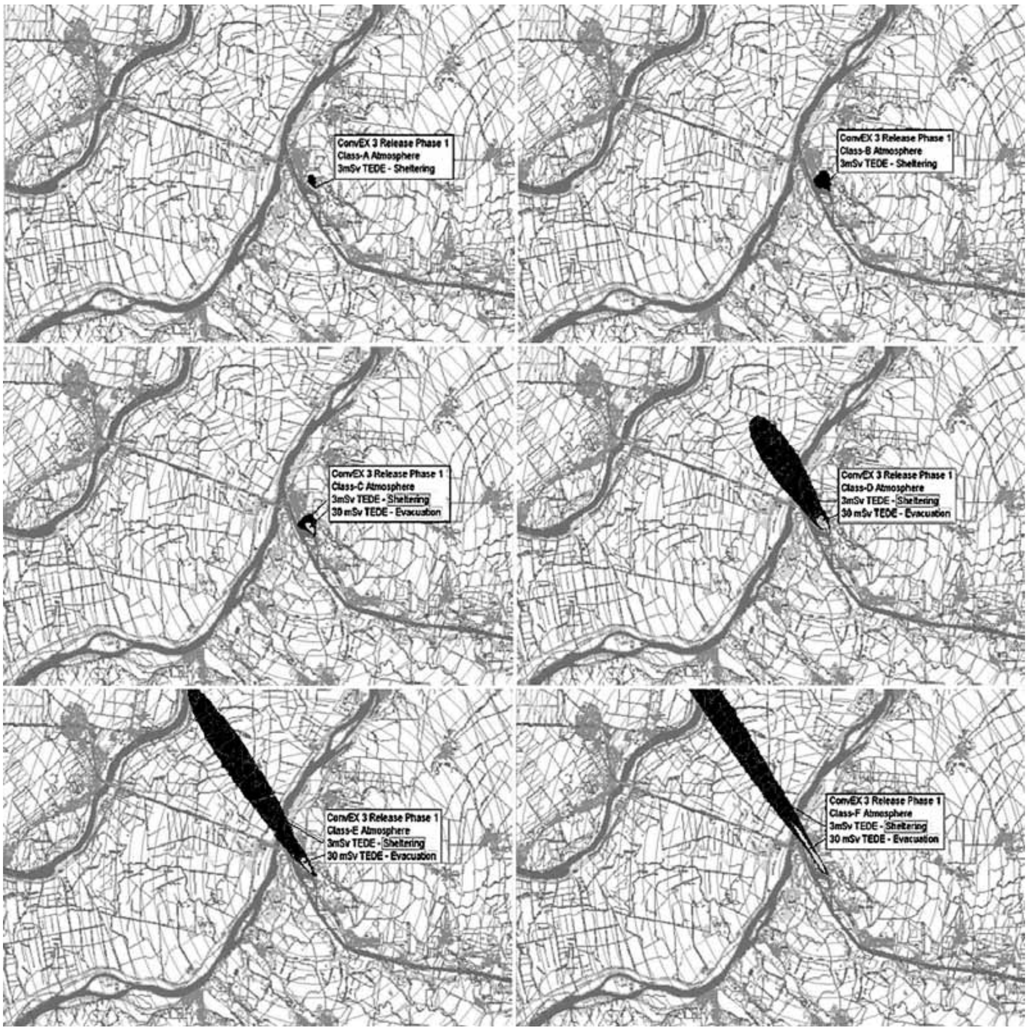

Fig. 2 – RAT results: reference dose areas, by atmospheric stability (Pasquill A, B, C, D, E, F).

Of a special relevance was a *prognostic* variety of RAT output, indicating the *vulnerability* induced in the populated territory around the (simulated) release sources, by the abnormal events in point. Fig. 4 renders a virtual dose of relevance for the population at large (*i.e.* in excess of the total acceptable allowance of 1 mSv per year from all irradiation sources) that would have been received by persons residing in the area exposed by the Cernavoda release, *should the release have continued for 48 hours of meteorological forecast on site*. This sort of looking ahead to a potentially aggravated scenario, yet based on *probable* data (the meteo forecast) as opposed to purely simulated data was noted with interest by the decidents in the Situation Room of the exercises.

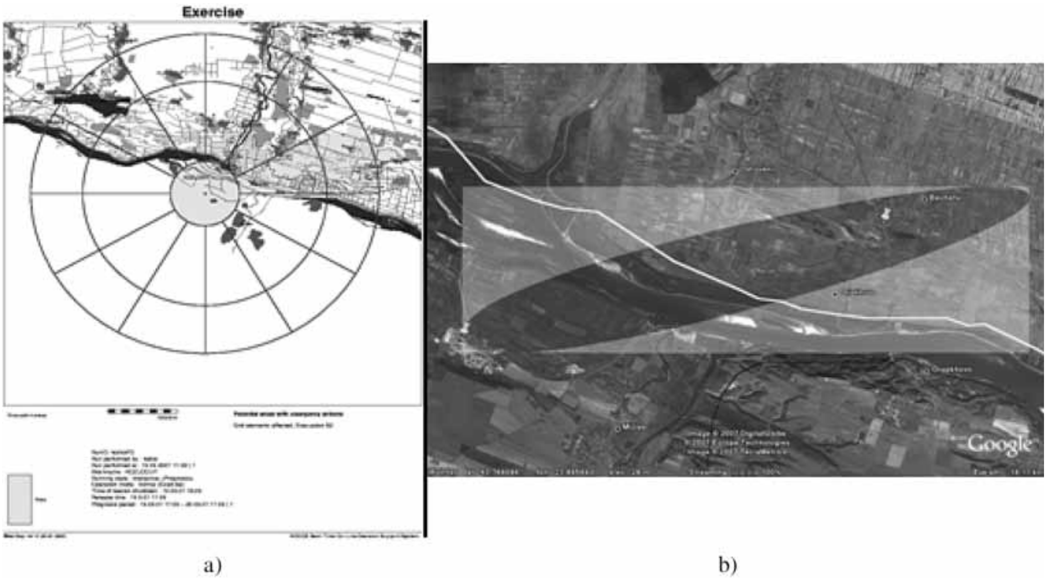

Fig. 3 – Evacuation area at Bechet, near Kozloduy, by: a) RODOS; b) RAT.

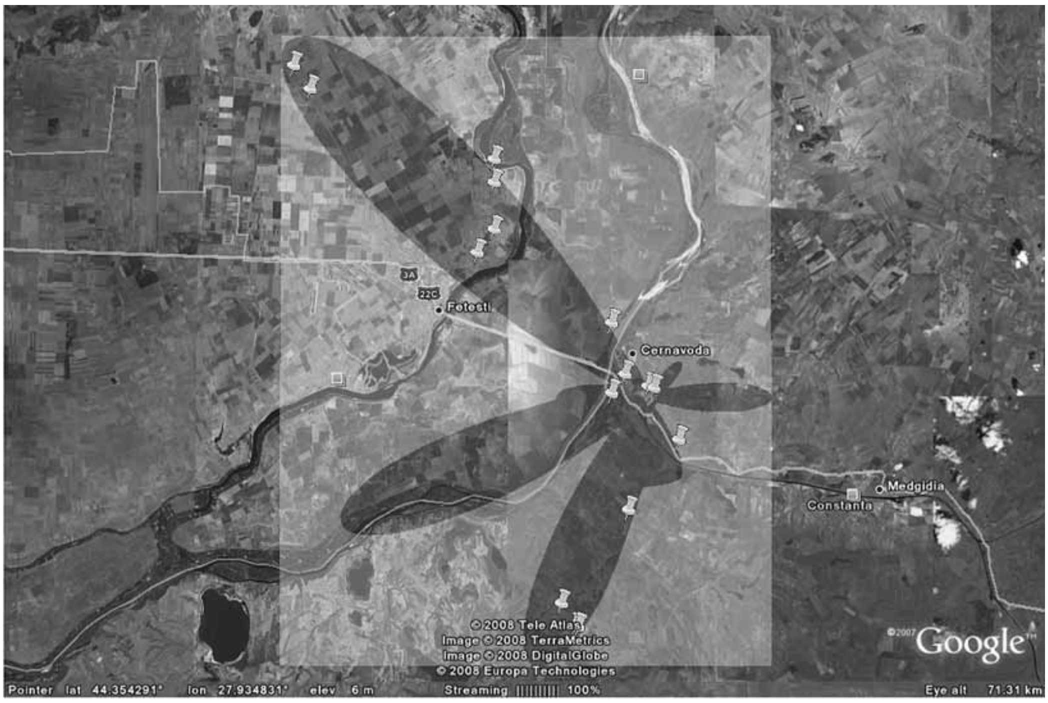

Fig. 4 – Assessing the 48-hour vulnerability induced by an accidental environmental release-in-process (of yet unknown duration) of radioactivity, at Cernavoda NPP. Pinpoints are GIS-linked and referred upon community sites. With RAT, such static images has *Google Earth* (TM) dynamic counterparts (KML files).

The *ConvEX-3* International Nuclear Alert Exercise [5] has provided an opportunity to check the validity of several working assumptions and postures adopted over the years by NIPNE in the nuclear emergency preparedness and response business.

Outstanding, from authors' standpoint, were:

a) The confirmation shared by the various authorities and technical expert parties present and participating in the exercise, of the fact that RODOS is indeed a viable and functional decision support system, worth implementation in the National Emergency Center.

b) The reiterated confirmation of the fact that the needs of the varied 'stakeholders' of the decision support systems – essentially, in this case – of the Civil Defense response ranks – go far beyond the mere knowledge of the contaminated air advection and diffusion – into the intricacies of the *dose and derived intervention level assessment*, *countermeasure design*, *consequence costs determination*, and *cost-benefit analyses of response* – a kind of information that, for the time being, only RODOS is equipped to deliver in an internally-consistent manner and at the required QA (quality-assurance) level.

c) A renewed evidence for the fact that the ancillary support with the origin in domestically-developed DSS facilities, like *e.g.* RAT, may prove valuable and non-conflicting with a full, mainstream commitment to promoting RODOS as *the* reference, nation-wide applied, and internationally recognized DSS for the management of nuclear emergencies in Europe.

d) The clear indications that the shift in paradigm currently experienced in Safety management – nuclear and other – worldwide, from *risk* assessment to a more comprehensive *vulnerability* assessment should be properly reflected not only in the deontology of the crisis/disaster responders, but also in the tools intended by the R&D contributors to assist these.

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